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(54) Suture anchor

Anker für Nähgarn

Ancrage pour sutures

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Description**BACKGROUND OF THE INVENTION**

[0001] The present invention relates generally to anchors for securing sutures to bone and more specifically to threaded suture anchors adapted to be screwed into bone.

[0002] There are many surgical procedures which require attaching a suture to a bone in order that the suture may be used to hold soft tissue adjacent the bone. Examples of such procedures include the reattachment and repair of torn tendons and ligaments in the knee, shoulder and hand. Various suture anchors have been proposed and used with varying success. U.S. Patent 4,898,156 teaches a suture anchor with an elastic barb which can be pressed into a hole formed in a bone. A suture is threaded through the suture anchor and is retained in the suture anchor by a knot tied in one end of the suture. The suture anchor resists displacement due to forces on the suture because of the action of the elastic barb in digging into the side of the hole formed in the bone. U.S. Patent 5,102,421 teaches a suture anchor having a series of concentric conical barbs which form a sharp point. The suture anchor is designed to be impacted into the bone. The conical barbs form a hole in the bone as they are driven into the bone and the barbs resist withdrawal of the suture anchor from the hole thus formed. A suture is attached to the suture anchor by crimping an extension of the suture anchor onto one end of the suture. Both of these prior art suture anchors provide a single strand of suture extending from the bone and fixed at one end to the bone.

[0003] Others have taught the advantages of a suture anchor secured to bone by the positive and well defined engagement of a helical screw thread with a corresponding thread formed in the bone. U.S. Patent 4,632,100 teaches a suture anchor for turning into a bone, comprising a shaft with a screw thread thereon. A double end of suture is attached to the suture anchor by securing a knot behind a washer dressed into a hollow end of the shaft of the suture anchor. A driver engaging surface is also formed within the interior of the hollow end for receiving a driver. U.S. Patent 5,156,616 teaches a threaded suture anchor to which a double end of suture is attached. This suture anchor is cannulated longitudinally. The knotted suture is drawn through the cannulation and is retained in the suture anchor because the knot cannot pass through the cannulation. This suture anchor also provides an internal driver engaging surface at one end. Both of these prior art threaded suture anchors retain a suture by trapping a knot within the suture anchor and therefore the suture ends are independently fixed to the anchor. In other words, tension on either of the protruding suture ends is resisted by the knot and tension on one of the ends does not cause the other end to slide through the device.

[0004] U.S. Patent Des. 331,463 depicts a threaded

suture anchor having an external driver engaging portion and an extending tab for receiving a suture. This configuration for a suture anchor works well for suture anchors which are small or made of delicate materials

5 such as bioresorbable materials. The external driver engaging portion and extending tab for the suture result in a greater cross sectional area in the body of the device than if it were designed like other suture anchors and therefore it is stronger. In addition, since the suture is
10 attached to the anchor by being threaded through an eye in the tab, it is easier for a surgeon to attach his suture of choice to the suture anchor at the time of surgery. Also, where the suture is threaded through an eye, the suture forms a continuous length and tension on one
15 end of the suture tends to cause the other end to slide through the suture anchor. This sliding action is advantageous in some procedures.

[0005] However, in very small anchors and especially
20 where delicate materials are used, the extending tab may be overly weak and break under tension. Conversely, the small size of the extending tab may cause it to cut through or kink the suture. Finally, the extending tab requires that the suture anchor be driven more deeply
25 into the bone than a suture anchor without such a tab in order to conceal the tab below the bone surface. This can make it difficult for the suture anchor to purchase cortical bone, especially where the cortical bone is thin.

SUMMARY OF THE INVENTION

30 [0006] The present invention overcomes the disadvantages of prior art devices and provides further advantages by providing a suture anchor with a shaft having a proximal and a distal end. A screw thread extends
35 from the shaft and spirals from the proximal to the distal end. A cross-hole is formed through the shaft and the screw thread near the proximal end. The cross-hole receives a suture which provides a double end of suture to facilitate attachment of soft tissue. The cross-hole allows a surgeon to use his suture of choice and it allows
40 one end of the suture to slide through the cross-hole when the other end is pulled. In addition, the cross-hole is located in an area of relatively large cross section with respect to the suture anchor generally. This results in
45 optimal tensile strength for the suture anchor and provides optimal contact area between the suture anchor and the suture to reduce the likelihood of cutting or kinking the suture. Since there is no extending tab, the anchor need not be driven as deeply as one having a tab.
50 This enhances the attachment of the suture anchor to the bone.

[0007] The strength of the suture anchor and the attachment of the suture anchor to the bone are further optimized, in a preferred embodiment, by tapering the
55 shaft from a larger diameter proximally to a smaller diameter distally. This increases the cross sectional area of the suture anchor proximally in the region of the cross-hole to increase strength while increasing the purchase

of the threads distally to increase the positive engagement of the threads into the bone distally to increase attachment strength.

[0008] The anchor has an externally driven portion adjacent the proximal end. The externally driven portion is stronger than an internally driven portion of the same outside dimensions would be, especially in small sizes or where delicate materials are used. The driven portion preferably contains a groove to conduct the suture from the cross-hole to the free end of the driven portion. A driver for the suture anchor having an engagement portion for engaging the driven portion likewise contains a groove so that when the engagement portion engages the driven portion the two grooves align to form an enclosed passageway for conducting the suture as the suture traverses the driven portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a perspective view of the preferred embodiment of the suture anchor of the present invention.

[0010] FIG. 2 is a top view of the suture anchor of FIG. 1.

[0011] FIG. 3 is a front view of the suture anchor of FIG. 1.

[0012] FIG. 4 is a side view of the suture anchor of FIG. 1.

[0013] FIG. 5 is a sectional view taken along line A-A of FIG. 3.

[0014] FIG. 6 is a sectional view taken along line B-B of FIG. 3.

[0015] FIG. 7 is a sectional view taken along line C-C of FIG. 3.

[0016] FIG. 8 is a side view of the driver of the present invention in engagement with the suture anchor of the present invention.

[0017] FIG. 9 is a sectional view taken along line D-D of FIG. 8.

[0018] FIG. 10 is a side view of the driver of the present invention.

[0019] FIG. 11 is an end view of the driver of FIG. 10.

DETAILED DESCRIPTION OF THE INVENTION

[0020] Referring to FIGS. 1-7, a suture anchor 1 includes a shaft 2 having a longitudinal axis and a proximal end 3 and a distal end 4. Preferably the shaft 2 is solid or, in other words, the shaft 2 is not cannulated along the longitudinal axis. A screw thread 5 extends from the shaft 2 and spirals around the longitudinal axis from the proximal end 3 to the distal end 4. Preferably, the screw thread 5 is continuous and uninterrupted between the proximal end 3 and distal end 4. A driven portion 7 is formed near the proximal end 3 and extends outwardly away from the proximal end 3 and terminates at a free end 8. The driven portion 7 is adapted for positive engagement with a driver so as to facilitate the

transmission of torsional loads from the driver to the driven portion 7. The driven portion 7 has a cross-sectional area depicted in FIG. 5. The shaft and thread have a cross-sectional area depicted in FIG. 6. As can be seen in FIGS. 5 and 6, the cross-sectional area of the shaft 2 and screw thread 5 is larger than the cross-sectional area of the driven portion 7. A cross-hole 6 extends through the shaft 2 and the screw thread 5, preferably near the proximal end 3. The cross-hole 6 extends through the shaft 2 and screw thread 5 because this region is stronger than the driven portion 7 because of the larger cross-sectional area of the shaft 2 and screw thread 5.

[0021] In a preferred embodiment, the shaft 2 forms a tapering minor diameter of the suture anchor 1 and the screw thread 5 has a major diameter S which is constant over most of the length of the suture anchor 1. The shaft 2 preferably tapers linearly from a larger diameter near the proximal end 3 to a smaller diameter near the distal end 4. The included angle α of the tapering shaft 2 is in the range of 4° to 10° , preferably 6° to 7° . In this preferred embodiment, the driven portion 7 has a first cross-sectional area 9. The shaft 2 and screw thread 5 have a second cross-sectional area 10 corresponding approximately to the larger diameter of the tapering shaft 2. The shaft 2 and screw thread 5 have a third cross-sectional area 11 corresponding approximately to the smaller diameter of the tapering shaft 2 and within the length of the constant major diameter S. The second cross-sectional area 10 is greater than both the first cross-sectional area 9 and the third cross-sectional area 11. The cross-hole 6 is formed through the shaft 2 and screw thread 5 near the second cross-sectional area 10. Locating the cross-hole 6 near the largest cross-sectional area of the suture anchor 1 produces the least reduction in tensile strength of the suture anchor 1 and the least likelihood of the suture being cut or kinked by the suture anchor 1. Maintaining a constant major diameter S while tapering the shaft 2 distally, increases the purchase or depth of engagement of the screw thread 5 into the bone toward the distal end 4 of the suture anchor 1. By combining a screw thread 5 having a constant major diameter and a tapering minor diameter with a cross-hole 6 located near the largest cross-sectional area of the suture anchor 1, strength and bone engagement are optimized.

[0022] In the preferred embodiment, a groove 12 extends from the proximal end 3 adjacent the cross-hole 6 to the free end 8 of the driven portion 7. The groove 12 allows a suture threaded through the cross-hole 6 to subside into the driven portion 7 and the groove conducts the suture as the suture traverses the driven portion 7.

[0023] Referring to FIGS. 8-11, a driver 13 comprises a rod 14 having an engagement portion 15 at an end of the rod 14. The engagement portion 15 has an inner surface 16 and an outer surface 17. The outer surface 17 is preferably smooth and uninterrupted so that it will not

abrade or catch tissues adjacent the bone when the driver 13 is turned to drive the anchor 1. The inner surface 16 is adapted for positive engagement with the driven portion 7 so as to facilitate the transmission of torsional loads from the driver 13 to the driven portion 7. The inner surface 16 preferably contains a groove 18. The groove 18 in the inner surface 16 aligns with the groove 12 in the driven portion 7 to form an enclosed passageway 19 for conducting the suture as the suture traverses the driven portion 7 when the engagement portion 15 engages the driven portion 7. The suture material extending beyond the free end 8 of the driven portion 7 is preferably contained inside the driver 13.

[0024] It will be understood by those skilled in the art that the foregoing has described a preferred embodiment of the present invention and that variations in design and construction may be made to the preferred embodiment without departing from the scope of the invention defined by the appended claims.

Claims

1. A suture anchor (1) for attaching a suture to a bone, the suture anchor (1) being drivable by a driver (13), the suture anchor (1) comprising:

a shaft (2), the shaft (2) having a longitudinal axis and a proximal end (3) and a distal end (4); a screw thread (5) extending from the shaft (2) and spiraling from the proximal end (3) to the distal end (4), the shaft (2) containing a cross-hole (6) near the proximal end (3), the cross-hole (6) extending through the shaft (2) and the screw thread (5); and a driven portion (7) formed adjacent the proximal end (3), the driven portion (7) being adapted for positive engagement with the driver (13) so as to facilitate the transmission of torsional loads from the driver (13) to the driven portion (7).

2. The suture anchor (1) of claim 1, wherein the driven portion (7) extends outwardly away from the proximal end (3) and terminates at a free end (8), the driven portion (7) including a groove (12) extending from the proximal end (3) of the shaft (2) adjacent the cross-hole (6) to the free end (8) of the driven portion (7) for conducting the suture as the suture traverses the driven portion (7).

3. The suture anchor (1) of claim 1, wherein the shaft (2) forms a tapering minor diameter of the suture anchor (1), the shaft (2) tapering linearly from a larger diameter near the proximal end (3) to a smaller diameter near the distal end (4), the cross-hole (6) extending through the shaft (2) and the screw thread (5) at the location of the larger diameter.

4. The suture anchor (1) of claim 3, wherein the included angle of the tapering minor diameter is in the range of from 4° to 10°.

5. A suture anchor (1) for attaching a suture to a bone, the suture anchor (1) comprising:

a conical shaft (2) forming a tapering minor diameter of the suture anchor (1), the shaft (2) having a longitudinal axis; a driven portion (7) formed at an end of the shaft and having a first cross-sectional area (9); and a screw thread (5) extending from the shaft (2) and spiraling the length of the shaft (2), the screw thread (5) having a major diameter (S) which is constant over most of its length, the shaft (2) and screw thread (5) having a second cross-sectional area (10) corresponding to the area near the proximal end (3) and a third cross-sectional area (11) corresponding to an area having a smaller minor diameter but still within the constant major diameter (S), the shaft (2) tapering smoothly from the second cross-sectional area (10) to the third cross-sectional area (11), the second cross-sectional area (10) being greater than both the first (9) and third (11) cross-sectional areas, the shaft (2) having a cross-hole (6) extending through the shaft (2) and the screw thread (5) near the second cross-sectional area (10).

6. In combination:

a suture anchor (1) comprising a shaft (2), the shaft (2) having a proximal end (3) and a distal end (4); a screw thread (5) extending from the shaft (2) and spiraling from the proximal end (3) to the distal end (4), the shaft (2) containing a cross-hole (6) near the proximal end (3), the cross-hole (6) extending through the shaft (2) and the screw thread (5); a driven portion (7) formed adjacent the proximal end (3), the driven portion (7) including a groove (12) extending from the proximal end (3) of the shaft (2) adjacent the cross-hole (6) to the free end (8) of the driven portion (7) for conducting the suture as it traverses the driven portion (7); and a driver (13) comprising a rod (14) with an engagement portion (15) at an end of the rod (14), the engagement portion (15) having an inner surface (16) and an outer surface (17), the outer surface (17) being uninterrupted, the inner surface (16) being adapted for positive engagement with the driven portion (7) so as to facilitate the transmission of torsional loads from the driver (13) to the driven portion (7), the inner surface (16) containing a groove (18), the groove (18) in the inner surface (16) aligning

with the groove (12) in the driven portion (7) to form an enclosed passageway (19) for conducting the suture as the suture traverses the driven portion (7) when the engagement portion (15) engages the driven portion (7).

Patentansprüche

1. Fadenanker (1) zum Befestigen eines Fadens an einem Knochen, wobei der Fadenanker (1) durch einen Schraubendreher (13) einschraubar ist, wobei der Fadenanker (1) aufweist:

einen Schaft (2) mit einer Längsachse sowie einem proximalen Ende (3) und einem distalen Ende (4);
ein vom Schaft (2) ausgehendes Schraubengewinde (5), das sich spiralförmig vom proximalen Ende (3) zum distalen Ende (4) erstreckt, wobei der Schaft (2) in der Nähe des proximalen Endes (3) eine Querbohrung (6) aufweist, wobei die Querbohrung (6) durch den Schaft (2) und das Schraubengewinde (5) hindurchgeht; und
einen angrenzend an das proximale Ende (3) ausgebildeten Mitnehmerabschnitt (7), wobei der Mitnehmerabschnitt (7) für einen formschlüssigen Eingriff mit dem Schraubendreher (13) angepaßt ist, um die Übertragung von Torsionslasten vom Schraubendreher (13) auf den Mitnehmerabschnitt (7) zu erleichtern.

2. Fadenanker (1) nach Anspruch 1, wobei sich der Mitnehmerabschnitt (7) vom proximalen Ende (3) weg nach außen erstreckt und an einem freien Ende (8) endet, wobei der Mitnehmerabschnitt (7) eine Nut (12) aufweist, die sich von dem an die Querbohrung (6) angrenzenden proximalen Ende (3) des Schafts (2) zum freien Ende (8) des Mitnehmerabschnitts (7) erstreckt, um beim Durchlauf des Fadens durch den Mitnehmerabschnitt (7) den Faden zu führen.

3. Fadenanker (1) nach Anspruch 1, wobei der Schaft (2) einen sich verjüngenden Kerndurchmesser des Fadenankers (1) bildet, wobei der Schaft (2) sich linear von einem größeren Durchmesser nahe dem proximalen Ende (3) auf einen kleineren Durchmesser nahe dem distalen Ende (4) verjüngt, wobei die Querbohrung (6) an der Stelle des größeren Durchmessers durch den Schaft (2) und das Schraubengewinde (5) hindurchgeht.

4. Fadenanker (1) nach Anspruch 3, wobei der Spitzenwinkel des sich verjüngenden Kerndurchmessers im Bereich von 4° bis 10° liegt.

5. Fadenanker (1) zum Befestigen eines Fadens an einem Knochen, wobei der Fadenanker (1) aufweist:

einen konischen Schaft (2), der einen sich verjüngenden Kerndurchmesser des Fadenankers (1) bildet, wobei der Schaft (2) eine Längsachse aufweist;
einen Mitnehmerabschnitt (7), der an einem Ende des Schafts (2) ausgebildet ist und eine erste Querschnittsfläche (9) aufweist; und
ein Schraubengewinde (5), das vom Schaft (2) ausgeht und sich spiralförmig um die Länge des Schafts (2) erstreckt, wobei das Schraubengewinde (5) einen Außendurchmesser (S) aufweist, der über den größten Teil seiner Länge konstant ist, wobei der Schaft (2) und das Schraubengewinde (5) eine zweite Querschnittsfläche (10), die der Fläche in der Nähe des proximalen Endes (3) entspricht, und eine dritte Querschnittsfläche (11) aufweisen, die einer Fläche mit einem kleineren Kerndurchmesser entspricht, aber noch innerhalb des konstanten Außendurchmessers (S) liegt, wobei sich der Schaft (2) stetig von der zweiten Querschnittsfläche (10) zur dritten Querschnittsfläche (11) verjüngt, wobei die zweite Querschnittsfläche (10) sowohl größer als die erste (9) als auch größer als die dritte Querschnittsfläche (11) ist, wobei der Schaft (2) eine Querbohrung (6) aufweist, die in der Nähe der zweiten Querschnittsfläche (10) durch den Schaft (2) und das Schraubengewinde (5) hindurchgeht.

6. In Kombination:

Fadenanker (1) mit einem Schaft (2), wobei der Schaft (2) ein proximales Ende (3) und ein distales Ende (4) aufweist; einem Schraubengewinde (5), das vom Schaft (2) ausgeht und sich spiralförmig vom proximalen Ende (3) zum distalen Ende (4) erstreckt, wobei der Schaft (2) in der Nähe des proximalen Endes (3) eine Querbohrung (6) aufweist, wobei die Querbohrung (6) durch den Schaft (2) und das Schraubengewinde (5) hindurchgeht; einem angrenzend an das proximale Ende (3) ausgebildeten Mitnehmerabschnitt (7), wobei der Mitnehmerabschnitt (7) eine Nut (12) aufweist, die sich von dem an die Querbohrung (6) angrenzenden proximalen Ende (3) des Schafts (2) zum freien Ende (8) des Mitnehmerabschnitts (7) erstreckt, um beim Durchlauf des Fadens durch den Mitnehmerabschnitt (7) den Faden zu führen; und
Schraubendreher (13), der einen Stab (14) mit einem Eingriffsabschnitt (15) an einem Ende

des Stabs (14) aufweist, wobei der Eingriffsabschnitt (15) eine Innenfläche (16) und eine Außenfläche (17) aufweist, wobei die Außenfläche (17) ununterbrochen ist, wobei die Innenfläche (16) für einen formschlüssigen Eingriff mit dem Mitnehmerabschnitt (7) angepaßt ist, um die Übertragung von Torsionslasten vom Schraubendreher (13) zum Mitnehmerabschnitt (7) zu erleichtern, wobei die Innenfläche (16) eine Nut (18) enthält, wobei die Nut (18) in der Innenfläche (16) in Flucht mit der Nut (12) im Mitnehmerabschnitt (7) ist, um beim Durchlauf des Fadens durch den Mitnehmerabschnitt (7) einen geschlossenen Durchgang (19) zur Führung des Faden zu bilden, wenn sich der Eingriffsabschnitt (15) im Eingriff mit dem Mitnehmerabschnitt (7) befindet.

Revendications

1. Ancrage pour suture (1) pour attacher un fil de suture à un os, l'ancrage pour suture (1) pouvant être entraîné par un entraîneur (13), l'ancrage de suture (1) comprenant :

- un arbre (2), l'arbre (2) ayant un axe longitudinal et une extrémité proximale (3) et une extrémité distale (4) ;
- un filetage de vis (5) s'étendant à partir de l'arbre (2) et passant en spirale de l'extrémité proximale (3) à l'extrémité distale (4), l'arbre (2) ayant un trou traversant (6) près de l'extrémité proximale (3), le trou traversant (6) s'étendant à travers l'arbre (2) et le filetage de vis (5) ; et
- une portion menée (7) formée pour être adjacente à l'extrémité proximale (3), la portion menée (7) étant conçue pour un engagement positif avec l'entraîneur (13) de manière à faciliter la transmission de charges de torsion de l'entraîneur (13) à la portion menée (7).

2. Ancrage pour suture (1) selon la revendication 1, où la portion menée (7) s'étend vers l'extérieur au loin de l'extrémité proximale (3) et se termine à une extrémité libre (8), la portion menée (7) incluant une rainure (12) s'étendant de l'extrémité proximale (3) de l'arbre (12) adjacente au trou traversant (6) à l'extrémité libre (8) de la portion menée (7) pour conduire le fil de suture lorsque le fil de suture traverse la portion menée (7).

3. Ancrage pour suture (1) selon la revendication 1, où l'arbre (2) forme un diamètre mineur rétréci de l'ancrage de suture (1), l'arbre (2) diminuant linéairement d'un plus grand diamètre près de l'extrémité proximale (3) à un plus petit diamètre près de l'extrémité distale (4), le trou traversant (6) s'étendant

à travers l'arbre (2) et le filetage de vis (5) à l'emplacement du plus grand diamètre.

4. Ancrage pour suture (1) selon la revendication 3, où l'angle inclus du diamètre mineur rétréci se situe dans la plage de 4° à 10°.

5. Ancrage pour suture (1) pour attacher un fil de suture à un os, l'ancrage de suture (1) comprenant :

- un arbre conique (2) formant un diamètre mineur rétréci de l'ancrage de suture (1), l'arbre (2) ayant un axe longitudinal ;
- une portion menée (7) formée à une extrémité de l'arbre et ayant une première zone en section transversale (9) ; et
- un filetage de vis (5) s'étendant à partir de l'arbre (2) et passant en spirale sur la longueur de l'arbre (2), le filetage de vis (5) ayant un diamètre majeur (S) qui est constant sur presque toute sa longueur, l'arbre (2) et le filetage de vis (5) ayant une deuxième zone en section transversale (10) correspondant à la zone près de l'extrémité proximale (3) et une troisième zone en section transversale (11) correspondant à une zone ayant un diamètre mineur plus petit mais toujours dans le diamètre majeur constant (S), l'arbre (2) diminuant régulièrement depuis la deuxième zone en section transversale (10) à la troisième zone en section transversale (11), la deuxième zone en section transversale (10) étant plus grande que la première (9) et la troisième (11) section transversale ensemble, l'arbre (2) ayant un trou traversant (6) s'étendant à travers l'arbre (2) et un filetage de vis (5) près de la deuxième zone en section transversale (10).

6. En combinaison :

un ancrage de suture (1) comprenant un arbre (2), l'arbre (2) ayant une extrémité proximale (3) et une extrémité distale (4) ; un filetage de vis (5) s'étendant de l'arbre (2) et passant en spirale de l'extrémité proximale (3) à l'extrémité distale (4), l'arbre (2) contenant un trou traversant (6) près de l'extrémité proximale (3), le trou traversant (6) s'étendant à travers l'arbre (2) et le filetage de vis (5) ; une portion menée (7) formée pour être adjacente à l'extrémité proximale (3), la portion menée (7) incluant une rainure (12) s'étendant de l'extrémité proximale (3) de l'arbre (2) adjacente au trou traversant (6) à l'extrémité libre (8) de la portion menée (7) pour conduire le fil de suture lorsqu'il traverse la portion menée (7) ; et
un entraîneur (13) comprenant une tige (14) avec une portion d'engagement (15) à une ex-

trémité de la tige (14), la portion d'engagement (15) ayant une surface interne (16) et une surface externe (17), la surface externe (17) étant ininterrompue, la surface interne (16) étant conçue pour un engagement positif avec la portion menée (7) de manière à faciliter la transmission des charges de torsion de l'entraîneur (13) à la portion menée (7), la surface interne (16) contenant une rainure (18), la rainure (18) dans la surface interne (16) étant alignée avec la rainure (12) dans la portion menée (7) pour former un passage fermé (19) pour conduire le fil de suture lorsque le fil de suture traverse la portion menée (7) lorsque la portion d'engagement (15) vient en prise avec la portion menée (7). 5
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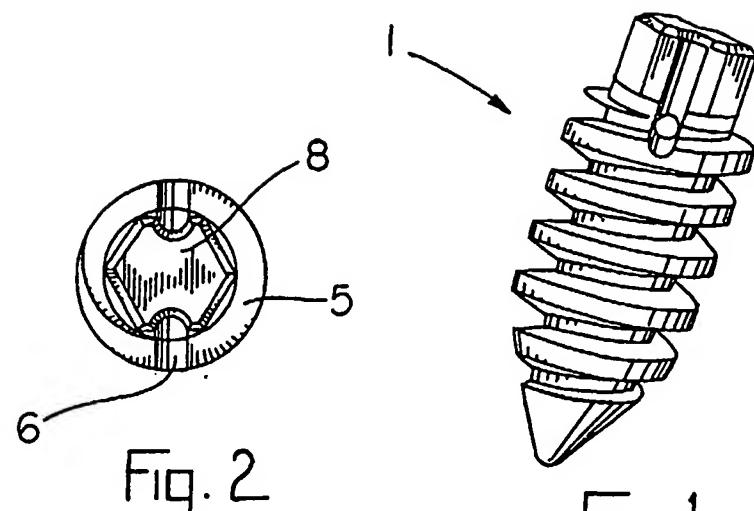


Fig. 2

Fig. 1

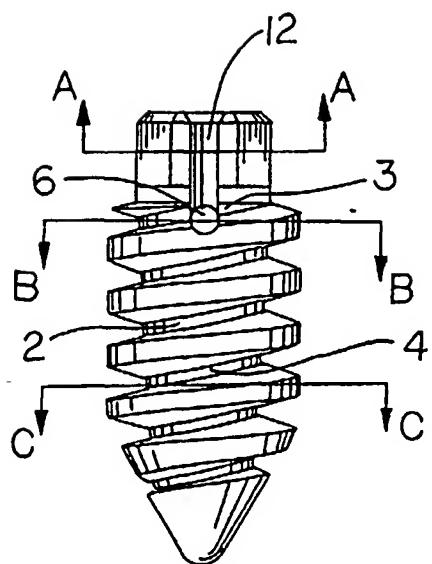


Fig. 3

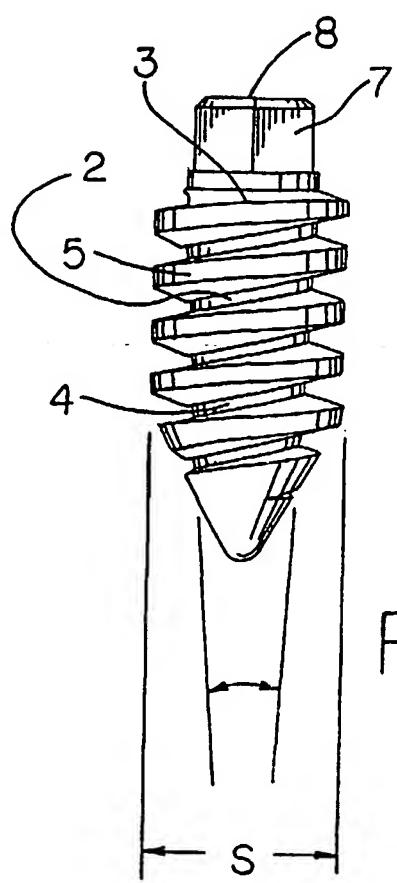


Fig. 4

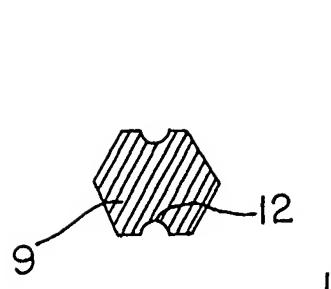


Fig. 5

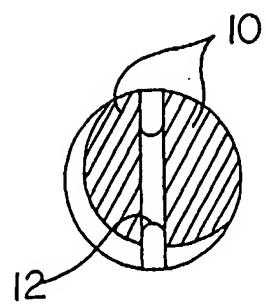


Fig. 6

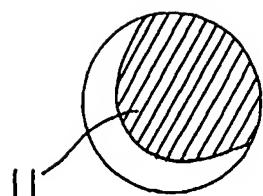


Fig. 7

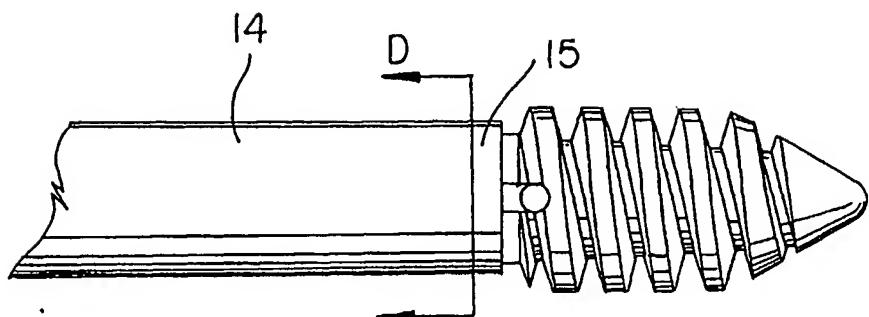


Fig. 8

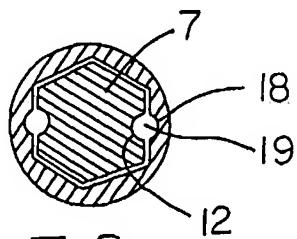


Fig. 9

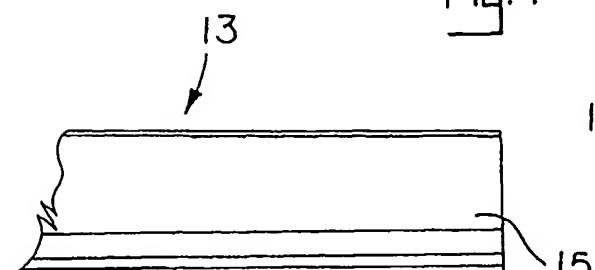


Fig. 10

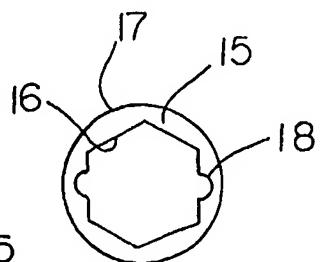


Fig. 11